

AMENDMENTS TO THE CLAIMS

Applicant submits below a complete listing of the current claims, including marked-up claims with insertions indicated by underlining and deletions indicated by strikeouts and/or double bracketing. This listing of claims replaces all prior versions, and listings, of claims in the application:

1. (Currently amended) A method for determining placement locations of Internet Transit Access Points (ITAPs) in a network, the method comprising:

(a) accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising nodes and links between the nodes, the connectivity information comprising link capacity constraints, node capacity constraints, node demands for flow, and a set of potential ITAPs to be opened, each ITAP in the set of potential ITAPs to be opened having a placement location;

(b) employing a processor executing computer-executable instructions to perform acts of:

(i) iterating through each ITAP in the set of potential ITAPs to be opened, in each iteration:

(I) selecting a test ITAP, from the set of potential ITAPs to be opened, to be added to a set of currently open ITAPs; and

(II) computing node demands satisfied if the test ITAP is added to the set of currently open ITAPs;

(ii) selecting, as a new ITAP for the network, the test ITAP from the set of potential ITAPs having a maximum computed value of the node demands satisfied when opened together with ITAPs in the set of currently open ITAPs;

(iii) adding the selected new ITAP to the set of currently opened ITAPs; and

(iv) repeating the iterating, selecting, and adding until all the node demands are satisfied; and

(c) implementing each ITAP in the set of currently opened ITAPs in the network at its respective placement location.

2. (Canceled)

3. (Previously Presented) The method of claim 1 wherein the computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

formulating a max-flow problem, wherein the max-flow problem computes the amount of node demands that can be satisfied under a given set of opened ITAPs when network throughput is independent of network path length;

creating a subgraph induced on a set of nodes, a set of currently opened ITAPs, and the test ITAP;

transforming each node's capacity constraint to an edge capacity constraint by replacing each node with a first node and a second node, the first node accepting all incoming edges to the transformed node and all outgoing edges from the transformed node originating from the second node, and creating a directed edge, having the node's capacity, from the first node to the second node;

adding a source node, the source node having edges of capacity equal to the demand of the transformed node from the source to each node in the network;

adding a destination node, the destination node having edges of capacity equal to the capacity of each currently opened ITAP and the potential ITAP to be opened, from each currently opened ITAP and the potential ITAP to be opened to the destination node; and

computing the maximum flow from the source node to the destination node.

4. (Previously Presented) The method of claim 1 wherein computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the test ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as independent of path length;

modifying the linear program to ensure that flow from each node is served by independent paths;

modifying the linear program to multiply the node demand by the number of independent paths;

modifying the linear program to multiply the capacity constraints by a ratio of an over-provisioning factor to the number of independent paths; and

solving the resulting linear program.

5. (Previously Presented) The method of claim 1 wherein computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

finding a shortest path from demand points to opened ITAPs;

routing one unit of flow along the shortest path;

decreasing capacities of edges on the path by one; and

repeating the finding, routing, and decreasing until the shortest path found has a length greater than a hop-count bound.

6. (Previously Presented) The method of claim 1 wherein computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

finding a shortest path from demand points to opened ITAPs;

routing one unit of flow along the shortest path;

decreasing capacities of edges on the path by one;

repeating the finding, routing, and decreasing until no path between any demand point and any open ITAP remains; and

computing a demand satisfied along each path according to a throughput function.

7. (Previously Presented) The method of claim 1 wherein computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the test ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as a function of a number of hops the connection traverses;

denoting an amount of flow routed through an edge based on a position of the edge along a path;

modifying the linear program to limit the maximum flow from each node; and
solving the resulting linear program.

8. (Previously Presented) The method of claim 1 wherein computing the node demands satisfied if the test ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the selected ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as a function of a number of hops the connection traverses;

modifying the linear program to ensure that flow from each node is served by independent paths;

modifying the linear program to multiply the node demand by the number of independent paths;

modifying the linear program to multiply the capacity constraints by a ratio of an over-provisioning factor to the number of independent paths; and

solving the resulting linear program.

9. (Canceled)

10. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

formulating a max-flow problem, wherein the max-flow problem computes the amount of node demands that can be satisfied under a given set of opened ITAPs when network throughput is independent of network path length;

creating a subgraph induced on a set of nodes, a set of currently opened ITAPs, and a potential ITAP to be opened;

transforming each node's capacity constraint to an edge capacity constraint by replacing each node with a first node and a second node, the first node accepting all incoming edges to the transformed node and all outgoing edges from the transformed node originating from the second node, and creating a directed edge, having the node's capacity, from the first node to the second node;

adding a source node, the source node having edges of capacity equal to the demand of the transformed node from the source to each node in the network;

adding a destination node, the destination node having edges of capacity equal to the capacity of each currently opened ITAP and the potential ITAP to be opened, from each currently opened ITAP and the potential ITAP to be opened to the destination node; and

computing the maximum flow from the source node to the destination node.

11. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the selected ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as independent of path length;

modifying the linear program to ensure that flow from each node is served by independent paths;

modifying the linear program to multiply the node demand by the number of independent paths;

modifying the linear program to multiply the capacity constraints by a ratio of an over-provisioning factor to the number of independent paths; and

solving the resulting linear program.

12. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

finding a shortest path from demand points to opened ITAPs;
routing one unit of flow along the shortest path;
decreasing capacities of edges on the path by one; and
repeating the finding, routing, and decreasing until the shortest path found has a length greater than a hop-count bound.

13. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

finding a shortest path from demand points to opened ITAPs;
routing one unit of flow along the shortest path;
decreasing capacities of edges on the path by one;
repeating the finding, routing, and decreasing until no path between any demand point and any open ITAP remains; and
computing a demand satisfied along each path according to a throughput function.

14. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the selected ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as a function of a number of hops the connection traverses;

modifying the linear program to limit the maximum flow from each node; and solving the resulting linear program.

15. (Previously Presented) The computer-readable storage medium of claim 16 wherein computing the node demands satisfied if the selected ITAP is added to the set of currently open ITAPs comprises:

developing a linear program to compute maximum demands satisfied in the wireless neighborhood network by opening the selected ITAP in conjunction with the set of currently opened ITAPs, wherein the linear program treats throughput of a connection as a function of a number of hops the connection traverses;

modifying the linear program to ensure that flow from each node is served by independent paths;

modifying the linear program to multiply the node demand by the number of independent paths;

modifying the linear program to multiply the capacity constraints by a ratio of an over-provisioning factor to the number of independent paths; and

solving the resulting linear program.

16. (Previously Presented) A computer-readable storage medium comprising computer-executable instructions that, when executed, perform a method for determining placement locations of Internet Transit Access Points (ITAPs) in a network, the method comprising:

accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising nodes and links between the nodes, the connectivity information comprising link capacity constraints, node capacity constraints, node demands for flow, and a set of potential ITAPs to be opened, each ITAP in the set of potential ITAPs having a potential placement location;

selecting an ITAP, from the set of potential ITAPs to be opened, to be added to a set of currently open ITAPs;

computing node demands satisfied if the selected ITAP is added to the set of currently open ITAPs;

when the computing indicates the selected ITAP increases the node demands satisfied when opened together with ITAPs in the set of currently open ITAPs, adding the selected ITAP to the set of currently opened ITAPs; and

repeating the selecting, computing, and adding until all the node demands are satisfied.

17. (Currently amended) A method for determining placement locations of access points in a network, the method comprising:

(a) accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising nodes and links between the nodes, the connectivity information comprising link capacity constraints, node capacity constraints, node demands for flow, a set of potential access points to be opened, and a set of time intervals, each access point in the set of potential access points having a potential placement location;

(b) employing a processor executing computer-executable instructions to perform acts of:

(i) iterating through the set of potential access points to be opened;

(ii) iterating through the set of time intervals;

(iii) for each time interval, computing a total of node demands satisfied by adding an ITAP from the set of potential access points to be opened, to a set of currently open access points;

(iv) selecting the access point that results in the largest increase in the sum of satisfied node demands over all time intervals;

(v) adding the selected access point to the set of currently opened access points; and

(vi) repeating the iterating, selecting, and adding until the node demands at all time intervals are satisfied; and

(c) implementing each access point in the set of currently opened access points in the network at its respective placement location,

wherein the set of currently opened access points provide Internet connectivity to the nodes.

18. (Previously Presented) A computer-readable storage medium comprising computer-executable instructions that, when executed, perform a method for determining placement locations of first nodes in a network, the method comprising:

accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising second nodes and links between the second nodes, the connectivity information comprising link

capacity constraints, second node capacity constraints, second node demands for flow, a set of potential first nodes to be opened, and a set of time intervals, each first node in the set of potential first nodes having a potential placement location;

iterating through the set of potential first nodes to be opened and through the set of time intervals, for each iteration:

selecting a test first node, from the set of potential first nodes to be opened, to be added to a set of currently open first nodes;

for each time interval, computing node demands satisfied if the test first node is added to a set of currently open first nodes; and

computing for the test first node a sum of the second node demands satisfied over all time intervals;

selecting, as a new first node for the network, the test first node that results in a largest increase in the sum of second node demands satisfied over all time intervals;

adding the selected new first node to the set of currently opened first nodes; and

repeating the iterating, selecting, and adding until the node demands at all time intervals are satisfied, wherein the first nodes are nodes configured to provide Internet connectivity.

19. (Currently amended) A method for determining placement locations of Internet Transit Access Points (ITAPs) in a network, the method comprising:

(a) accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising nodes and links between the nodes, the connectivity information comprising link capacity constraints, node capacity constraints, node demands for flow, a set of potential ITAPs to be opened, and a set of time intervals, each ITAP in the set of potential ITAPs having a potential placement location;

(b) employing a processor executing computer-executable instructions to perform acts of:

(i) iterating through the set of potential ITAPs to be opened, in each iteration:

(I) selecting a test ITAP, from the set of potential ITAPs to be opened, to be added to a set of currently open ITAPs; and

- (II) computing node demands satisfied by adding the test ITAP to a set of currently open ITAPs, wherein each node's demand is the node's maximum demand over all time intervals;
- (ii) selecting, as a new ITAP for the network, the test ITAP having a largest computed node demands satisfied;
- (iii) adding the selected new ITAP to the set of currently opened ITAPs; and
- (iv) repeating the iterating, selecting, and adding until the maximum node demands of all nodes are satisfied; and
- (c) implementing the set of currently opened ITAPs in the network.

20. (Previously Presented) A computer-readable storage medium comprising computer-executable instructions that, when executed, perform a method for determining placement locations of Internet access nodes in a network, the method comprising:

accepting connectivity information for the network, the network being a multi-hop wireless mesh network employing a contention-based media access control (MAC) protocol and comprising user nodes and links between the user nodes, the connectivity information comprising link capacity constraints, user node capacity constraints, user node demands for flow, a set of potential Internet nodes to be opened, and a set of time intervals, each Internet access node in the set of potential Internet access nodes having a potential placement location;

iterating through the set of potential Internet access nodes to be opened;

selecting an access point, from the set of potential Internet access nodes to be opened, that satisfies a largest user node demand;

adding the selected Internet access node to the set of currently opened Internet access nodes, wherein each user node's demand is the user node's maximum demand over all time intervals; and

repeating the iterating, selecting, and adding until the user node demands at all time intervals are satisfied.

21.-22. (Canceled)

23. (Currently amended) A method for reducing potential placement locations of Internet Transit Access Points (ITAPs) in a network by identifying equivalence classes of nodes in the network which may be serviced by the same ITAP, the method comprising:

(a) accepting equivalence class information for the network, wherein the network is a multi-hop wireless mesh network; and

(b) employing a processor executing computer-executable instructions to perform acts of:

(i) determining whether a first equivalence class is covered by a second equivalence class; and

(ii) eliminating the first equivalence class from consideration as a potential placement location for the ITAP if the first equivalence class is covered by the second equivalence class.

24. (Original) The method of claim 23 further comprising:
repeating the determining and eliminating until all equivalence classes covered by the second equivalence class have been identified.

25. (Previously Presented) A computer-readable storage medium comprising computer-executable instructions that, when executed, perform a method for reducing potential placement locations of Internet Transit Access Points (ITAPs) in a network by identifying equivalence classes of nodes in the network which may be serviced by the same ITAP, the method comprising:

accepting equivalence class information for the network, wherein the network is a multi-hop wireless mesh network;

determining whether a first equivalence class is covered by a second equivalence class; and

eliminating the first equivalence class from consideration as a potential placement location for the ITAP if the first equivalence class is covered by the second equivalence class.

26.-27. (Canceled)

28. (Previously Presented) The computer-readable storage medium of claim 20, wherein the Internet access nodes are Internet Transit Access Points.